

Advanced Gasification By-Product Utilization

Rodney Andrews, Aurora Rubel, Jack Groppo, David Graham, Ari Geertsema
University of Kentucky, Center for Applied Energy Research
2540 Research Park Drive
Lexington, KY 40511-8410
phone: 859-257-0209
fax: 859-257-0302
E-mail: rubel@caer.uky.edu

M.Mercedes Maroto-Valer, Zhe Lu, Harold Schobert
The Energy Institute, The Pennsylvania State University
405 Academic Activities Building
University Park, PA 16802-2398
phone: (814) 863-1337
E-mail: schobert@ems.psu.edu

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OBJECTIVES

The objectives of the work at the CAER were to investigate the potential use of gasifier slag carbons as a source of low cost sorbent for Hg and NO_x capture from combustion flue gas and as a source of activated carbons. Primary objectives are to determine the relationship of surface area, pore size, pore size distribution, and mineral content on Hg storage of gasifier carbons and to define the site of Hg storage. The ability of gasifier slag carbon to capture NO_x and the effect of NO_x on Hg adsorption are secondary goals.

Since gasifier chars have already gone through a devolatilization process in a reducing atmosphere in the gasifier, they only require to be activated to be used as activated carbons. Therefore, the principal objective of the work at PSU is to characterize and utilize gasification slag carbons for the production of activated carbons. Increasing the surface area of gasifier carbons should improve their NO_x adsorption potential. Testing the Hg and NO_x adsorption potential of these activated gasifier carbons is a secondary objective of this work.

ACCOMPLISHMENTS TO DATE

During the past year, the Hg adsorption capacities of four slag carbons obtained from two different gasification plants (A and B) were compared with respect to their Hg capture potential. One of these slag carbons, with high starting carbon content, was also investigated as a potential source of activated carbon. Two of the gasifier slag carbon samples had exceptional Hg capture potential. Factors found to influence good Hg adsorption on these carbons were the carbon and sulfur content, the high oxygen content, the presence of either Cl⁻ or SO₄⁻² or both. The carbon contents of the two best Hg sorbents were quite different (46 and ~80%) and yet they had nearly the same Hg adsorption capacity. This suggested that carbon content is not the sole determinant

of Hg capture potential. High Cl^- , F^- , and oxygen in these samples may be important in Hg capture since they have been implicated in the oxidation of Hg^0 to Hg^{+2} which is easier to remove from gas streams.

The surface areas of the two best Hg capturing gasifier carbons were over $100 \text{ m}^2/\text{g}$. However, the Hg capture capacities of the good Hg adsorbing gasifier carbons were higher than a specialty activated carbon developed specifically for Hg adsorption. The specialty carbon had a surface area of $570 \text{ m}^2/\text{g}$, suggesting that high surface area may not be important. Similarly, one of the poor Hg adsorbing gasifier carbons had higher surface area than the two that adsorbed well. However, some surface area must be required as samples with a surface area of less than $25 \text{ m}^2/\text{g}$ did not absorb any Hg. The results also indicate that the total pore volumes of good Hg adsorbing gasifier carbons were substantially greater than those which did not adsorb Hg, with the increased pore volume attributable to meso- and macro-pores.

Since most activated carbons have surface areas significantly above the $100 - 150 \text{ m}^2/\text{g}$ found for the Hg adsorbing gasifier carbons, it was initially expected that increased surface area would improve Hg and NO_x adsorption. Specialty carbons developed for Hg adsorption have surface areas significantly above that of the gasifier carbons. It was found that a one step steam activation process at 850°C applied to a good Hg adsorbing gasification char increased the surface area from 153 to $427 \text{ m}^2/\text{g}$. A parametric study conducted to understand the effect of activation time on the properties of the resultant activated carbon showed that the surface area and the percentage of micro-pores increased with the activation time at the expense of carbon yields and reach a maximum value at 120 minutes. The total pore volume increases continuously with activation time for the conditions studied.

FUTURE WORK

The relationship of surface area, pore size, pore size distribution, and mineral content especially Cl^- , F^- and O of gasifier carbons on Hg adsorption will be explored during the coming year in an effort to define the site of Hg storage. The results for Hg loaded gasifier carbons submitted for x-ray adsorption fine structure spectrometry, XAFS, will be available in 2005 and should shed light on the Hg adsorption sites in these gasifier slag carbons.

The activated carbon generated from the gasifier slag carbon at PSU will be tested for Hg and NO_x adsorption potential. All parent gasifier slag carbons will be tested for NO_x adsorption potential and the best Hg adsorbing carbons will be tested for both Hg and NO_x in a simulated flue gas.

Gasifier activated carbon will be tested for other uses such as coke additives.

PUBLICATION, PATENTS, AND PRESENTATIONS, STUDENTS

Presentation: Rubel, A.M.; Andrews, R.; Gonzalez, R.; Groppo, J.G.; Robl, T.L. "Mercury Adsorption on Combustion and Gasifier By-Products," 56th Southeastern Meeting of the American Chemical Society, Nov 11-12, Research Triangle Park, NC, 2004.

Students: David Graham, University of Kentucky; Zhe Lu, The Pennsylvania State University